(12) UK Patent Application (19) GB (11) 2 197 860 (13) A

(43) Application published 2 Jun 1988

(21) Application No 8719259

(22) Date of filing 14 Aug 1987

(30) Priority data
(31) 897184 (32) 15 Aug 1986 (33) US

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(51) INT CL⁴
C02F 9/00 B01D 13/02

(52) Domestic classification (Edition J):
C1C 412 413 414 41Y 447 460 LB

(56) Documents cited
GB A 2179646 GB A 2074998 GB A 2002736
EP A2 0056855 US 4265760 US 4145279
US 3836458 US 3774763

(58) Field of search
C1C
B1X
Selected US specifications from IPC sub-classes
C02F C02B B01D

(54) **Apparatus for and the method of water purification**

(57) An apparatus for the treatment of water includes a pretreatment filter to remove large scale particulate matter, an activated carbon filter, in ion exchanger, and an ultrafilter membrane. The carbon filter may be omitted or replaced with a sodium bisulfite injection stage to remove residual disinfectants in the water. This system permits colloidal and organic materials to pass through the system to the ultrafilter membrane where such materials are retained. Another embodiment, adapted for municipal water supplies includes a particulate removal stage, an ultrafiltration stage and a disinfecting stage.

A further embodiment includes the steps of removing particulate matter, removing residual disinfectants, and removing organic and colloidal materials in the water. Another embodiment includes the steps of removing particulate material in the water, removing bacteria and trihalomethane "precursors" in the water, and disinfecting the water.

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The drawings(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy

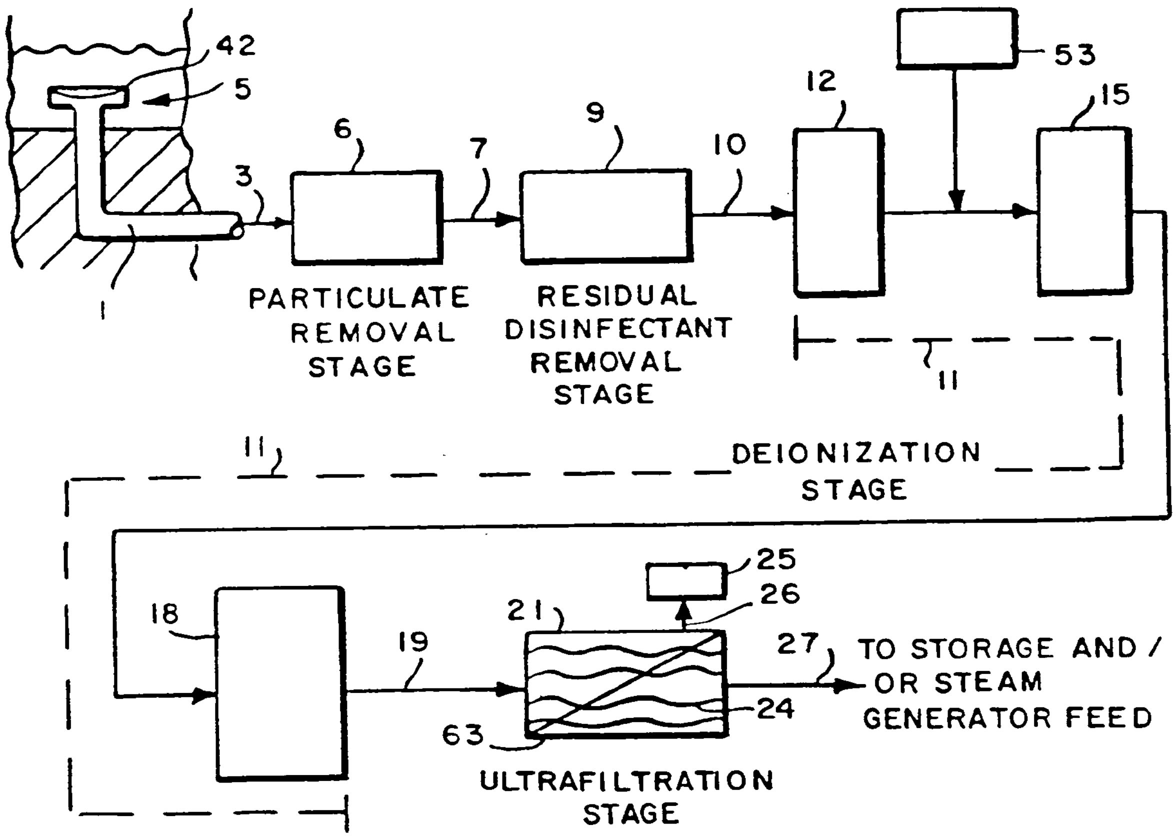
42
5
1
3
6
PARTICULATE REMOVAL STAGE
7
9
RESIDUAL DISINFECTANT REMOVAL STAGE
10
12
53
15
11
DEIONIZATION STAGE
11
18
19
21
25
26
27
TO STORAGE AND / OR STEAM GENERATOR FEED
24
63
ULTRAFILTRATION STAGE

FIG. 1

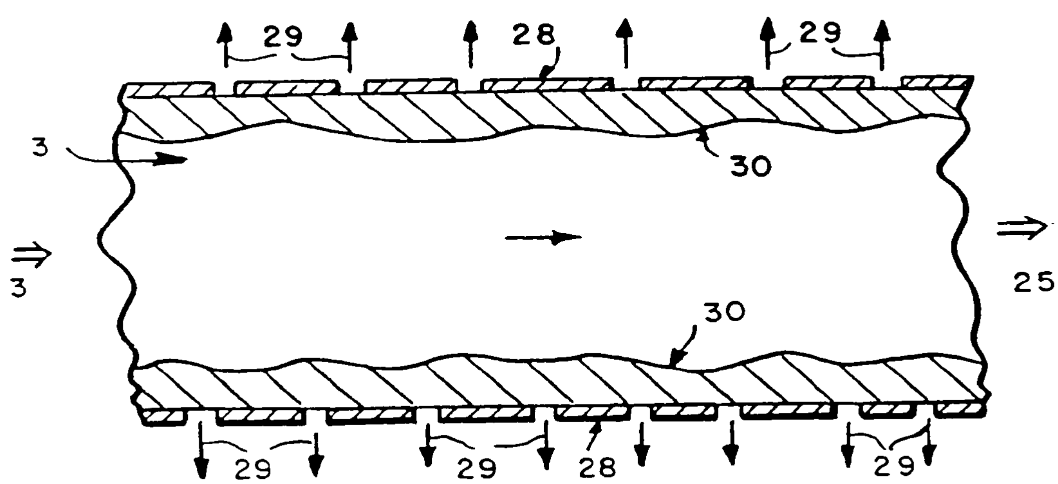
29
28
29
3
30
3
25
30
29
29
28
29

FIG. 2

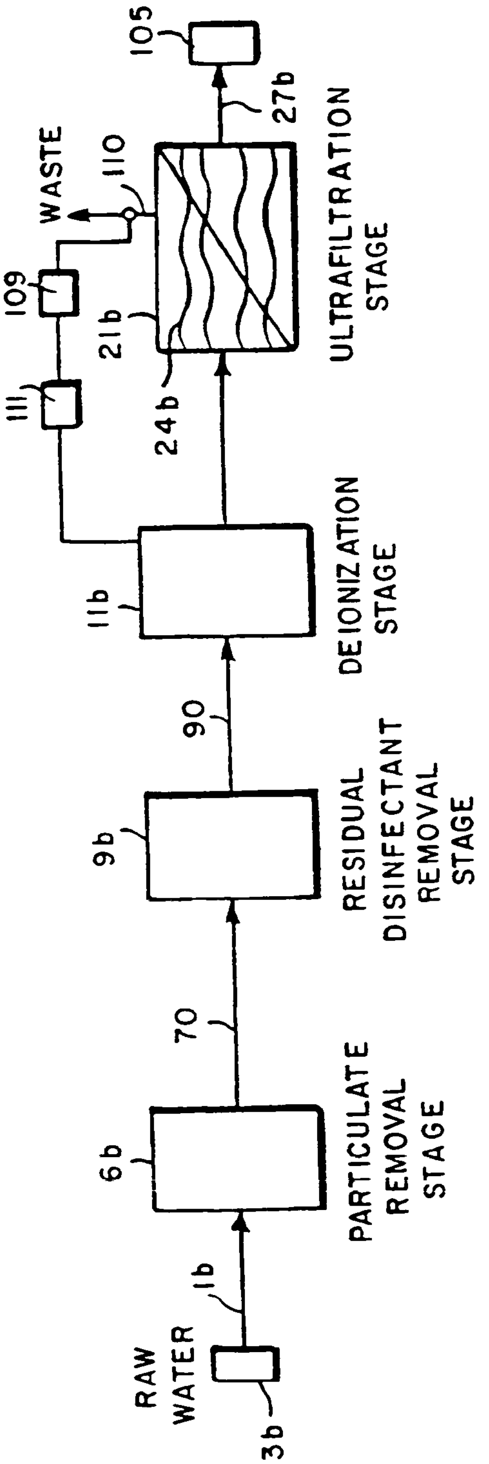
RAW WATER
3b
1b
6b
PARTICULATE REMOVAL STAGE
70
9b
RESIDUAL DISINFECTANT REMOVAL STAGE
90
11b
DEIONIZATION STAGE
111
109
WASTE
110
24b
21b
ULTRAFILTRATION STAGE
27b
105

FIG. 3

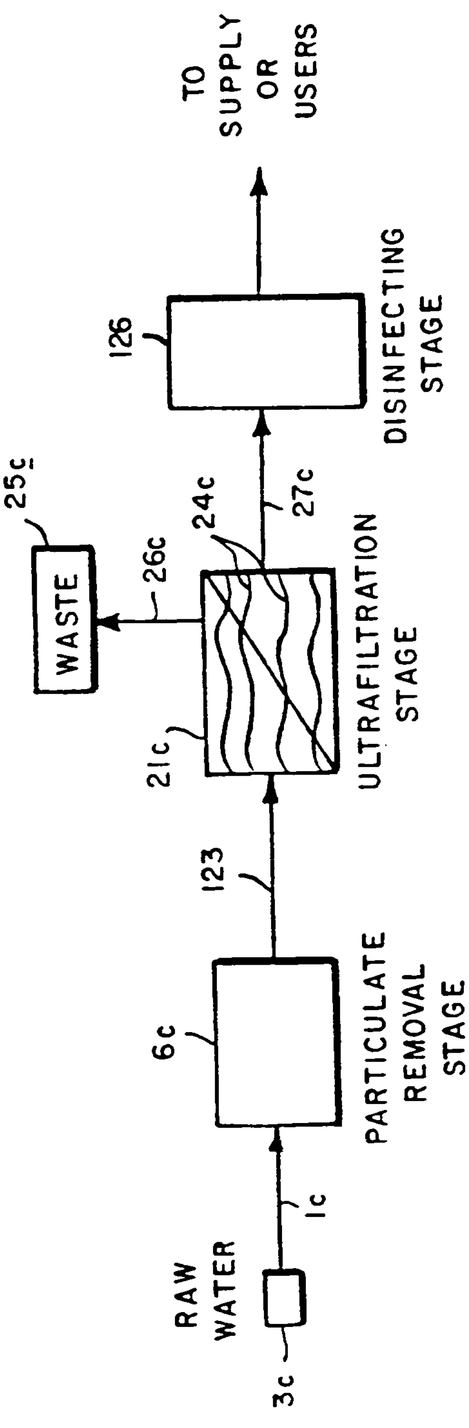
RAW WATER
3c
1c
6c
PARTICULATE REMOVAL STAGE
123
21c
ULTRAFILTRATION STAGE
WASTE
25c
26c
24c
27c
126
DISINFECTING STAGE
TO SUPPLY OR USERS

FIG. 4

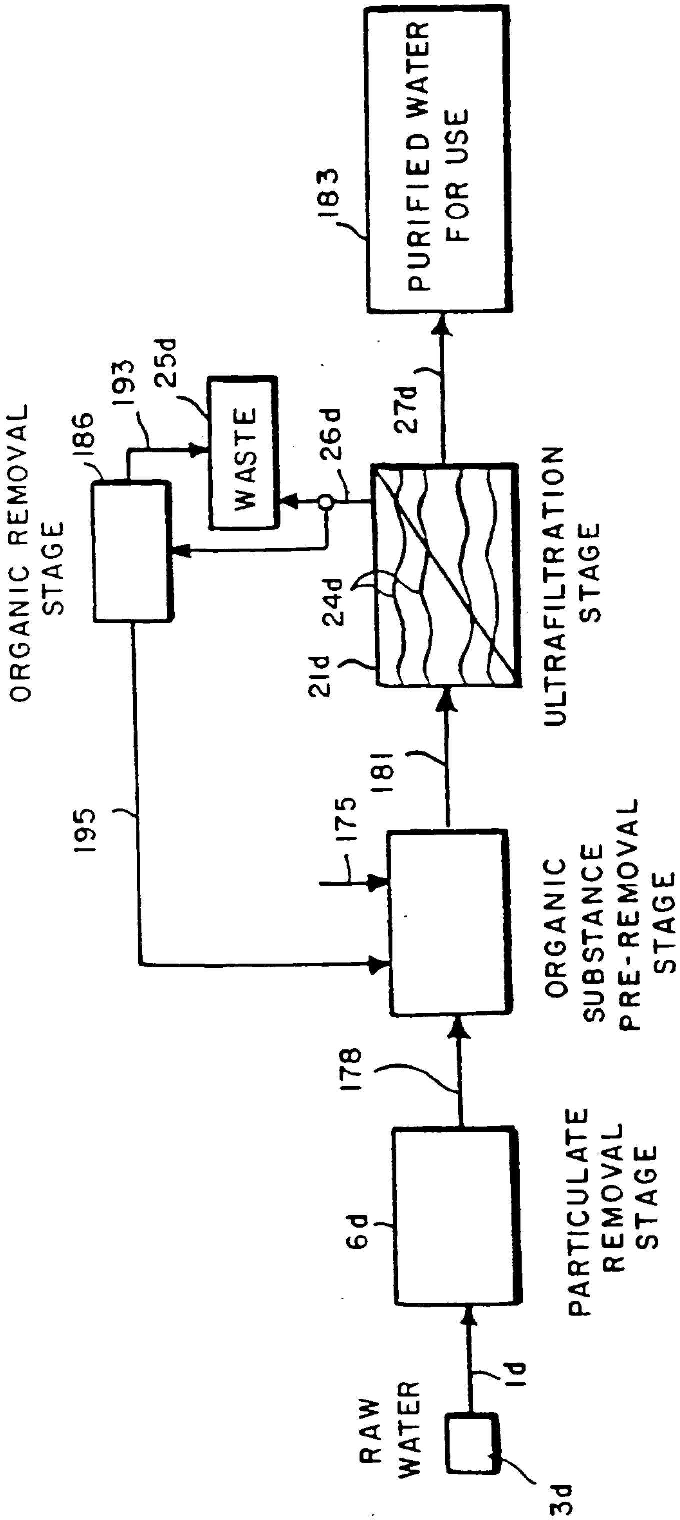
RAW WATER
3d
1d
6d
PARTICULATE REMOVAL STAGE
178
ORGANIC SUBSTANCE PRE-REMOVAL STAGE
175
195
181
21d
24d
ULTRAFILTRATION STAGE
ORGANIC REMOVAL STAGE
186
193
25d
WASTE
26d
27d
183
PURIFIED WATER FOR USE

FIG. 5

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APPARATUS FOR AND THE METHOD OF WATER PURIFICATION

This invention generally relates to an apparatus and method for the treatment of water and more particularly to an apparatus and method for the production of purified water having substantially no residual colloidal matter, free ions, organic material, or bacteria or combinations of the above, as necessary for the end use of such water.

Background of the Invention

The chemical and physical characteristics of water supplies which are processed for numerous users vary greatly. Water supplies are generally classified according to their sources, e.g. ground water, river water or reservoir water and, more generally, as either ground or surface water. Ground water and surface water exhibit several significant differences. Thus, ground water generally exhibits the characteristics of high alkalinity, high hardness levels, and higher concentrations of iron and manganese, as compared with surface water. On the other hand, surface water, particularly water from reservoirs, exhibits the characteristics of high sodium and chloride concentrations of iron and manganese, as compared to surface water. Surface water, particularly water from resevoirs, also exhibit the characteristics of high sodium and chloride concentrations as compared with ground water.

Another chief difference between surface and ground water supplies is that ground water will generally have little, if any, harmful bacteria, organic material, or colloidal matter present, while surface water supplies will usually contain significant quantities of all three items. These organic and colloidal materials are the root of many problems in the use of such water.

For instance, municipal water systems which provide potable water have in the past used and often still use a chlorine treatment to disinfect water from surface water sources. The presence of organic constituents in surface water at the time of chlorination generally leads to the production of trihalomethanes, which are believed to be carcinogenic. In fact, since about 1979, the United States Environmental Protection Agency (EPA) has established a limit of approximately 100 ppb of total trihalomethanes in drinking water. This has resulted in the treatment of water with chloramine compounds, which are not as efficient or effective as chlorine as a disinfectant.

Other water users, such as steam generation systems, using surface water treated by present methods, have experienced steam tube failures. These failures are evidently caused by impurities in the water. Examination of the failed tubes usually reveals significant buildup of chlorides and sulfates on steam tubes. This buildup is unexpected, as the water after standard treatment often reveals chloride and sulfate levels of only approximately 1-2 ppb by conventional testing. However, testing in a manner as described hereinafter discloses significantly higher concentrations and would, therefore account for such chloride and sulfate buildup.

Likewise, pharmaceutical manufacturers have also experienced problems with surface water that has been treated using processes standard in the pharmaceutical field. These present processes, which consist generally of a particulate removal step followed by activated carbon adsorption, ion exchange, and a final cartridge filtration, have not been entirely effective. The systems are often plagued by high bacteria levels

associated both with the use of activated carbon and with improper regeneration of the ion exchange equipment.

Prior methods for treating and purifying surface water for ultimate use in the above-described applications have generally involved attempts to remove organic and colloidal matter during the intial phases of the treatment process. The general belief has been that such matter is best removed at the early stages in order to avoid interference with the operation of subsequent phases of the process. Yet, these methods as pointed out above, have suffered from various drawbacks, inefficiencies, and deficiencies.

Thus, the problems associated with using surface water supplies are particularly serious, especially when one considers the dependence upon surface water sources for many and varied uses. Therefore, there has been a need for a relatively simple and adaptable apparatus and process of water treatment, which can produce water that is substantially free of organic, ionic, and colloidal matter, as well as bacteria. As will be appreciated by those skilled in the art, the ultimate use of the water may make elimination of one or more of these items unnecessary, and the below-described invention can be so applied.

Summary of the Invention

It is therefore an object of the present invention to provide a method and apparatus for use in the purification treatment of water for use in various industrial, personal, and municipal applications.

It is a further object of the invention to provide a method and apparatus for the removal of substantially all colloidal, organic, and ionic materials in water.

It is a further object of the present invention to provide a method and apparatus for the purification of water for use in steam generators which substantially reduces tube failure resulting from chloride and sulfate deposits.

It is another object of the present invention to provide a means and method for the purification of water for use in pharmaceutical industry.

It is yet another object of the present invention to provide a means and method for the purification and chlorination of surface water to produce potable water without trihalomethanes.

In brief, the new apparatus, which employs standard water purification devices arranged in a manner not heretofore known or used, includes in general a pretreatment filter to remove large scale particulate matter, an activated carbon filter, an ion exchanger, and an ultrafilter membrane. The carbon filter may in certain cases be omitted or replaced with a sodium bisulfite injection stage which reacts with and tends to remove residual disinfectants in the water. As will be seen, this system permits colloidal and organic materials to pass through the system to the ultrafilter membrane where such materials are retained.

The above-mentioned objects, as well as further objects and purposes of the invention, will be better understood when taken in connection with the below described details of the preferred embodiments of the invention.

Brief Description of the Drawings

Further explanation of this invention is illustrated in detail in accordance with the accompanying drawings as follows:

Fig. 1 is a block diagram of the apparatus of the present invention;

Fig. 2 is an enlarged cross section of one of the ultrafilter membranes of the apparatus of Fig. 1;

Fig. 3 is a block diagram of an alternative embodiment of the present invention;

Fig. 4 is a block diagram of an alternative embodiment of the present invention; and

Fig. 5 is a block diagram of yet another embodiment of the present invention.

Detailed Description of the Preferred Embodiments

Fig. 1 illustrates a block diagram of a water purification system for use in purification of water for steam tubes according to the present invention. The system has an inlet water feed or pipe 1 supplying surface water 3 from a surface water supply 5, in this case a reservoir. The feedwater 3 first passed to a particulate removal stage 6 that filters out large particulate matter. From the stage 6 the water passes through a pipe 7 to a residual disinfectant removal stage 9, which releases disinfectants that are present in the water. From the station 9 the water is directed through pipe 10 to a deionizing stage 11 which in this case comprises a cation bed 12, an anion bed 15 and a polishing or mixed bed 18. The water is then directed through pipe 19 to an ultrafiltration stage 21 which has a plurality of industrial ultrafilter membranes 24 arranged in parallel. Waste water 25 is directed from the membranes 24 through pipe 26, and water for use is directed through pipe 27.

The arrangement thus described operates to remove particulate matter in the water, replace ions in the water with hydrogen and hydroxyl ions which combine to

form water, and to remove organic and colloidal material within the water. Thus, the system produces pure water which has a variety of uses.

With reference to Fig. 1, the feedwater 3 is directed through the pipe 3 to the particulate removal stage 6. The particulate removal stage 6 is adapted to remove the larger scale contaminants of the feedwater 3, e.g. particles having a minimum size of between 5 to 10 microns. Thus, the stage 6 can be a simple sand bed. It will be appreciated by those skilled in the art that various other forms and combinations of particulate removal apparatus, which can be used as part of the present invention, include the standard types of filtration devices used in water purification, e.g. multi-media filters, dual media filters, or sand filters.

It will be understood that an initial filtration of the influent water 3 to remove large matter such as leaves and like material may be also useful in many cases. The mesh grate or screen 42 may be provided at the mouth of the pipe 1, or at other places within pipe 3, as may be convenient for use, inspection and maintenance.

The residual disinfectant removal stage 9 may, for example, be a reducing agent injection unit. Alternatively, the stage 9 may be an activated carbon filter. The disinfecting agents removed by the reducing agents or carbon filter are usually compounds of ions like hypochlorite ions or chloramines. These residual disinfectants are oxidants and their removal prolongs the effectiveness of the ion beds 12, 15, and 18.

A carbon filter, which is a depth filter, has the effect of having the residual disinfectant in the water passing therethrough by a chemi-adsorption reaction between the disinfectant and the activated carbon. The

activated carbon filter also has another feature in that the carbon acts to retain organic constituents in the water by adsorption. It will be recognized that the longer the filter is used, the more the heavier weight molecules bonding to the activated carbon will be dislodged by lighter weight molecules due to the weak nature of the Van der Waal forces holding such molecules to the carbon. Thus, it is possible that the concentration of such heavy molecules in the effluent water from the carbon filter 9b will be greater at times than the influent concentration of such molecules in the water 3. This occurrence may be of some benefit in certain uses of the invention, as will be discussed in greater detail below.

An example of a reducing agent which would be useful in the stage 9 is sodium bisulfite, which reacts with the residual oxidizing disinfectants in the water 3. I believe that both the reducing agent injection unit and the carbon filter, or any other device for reducing the quantity of the residual disinfectant in the water 3, may in some cases be unnecessary. That is, the disinfectant removal stage is an option to the present invention, and may be omitted, if the level of the residual disinfectants and other oxidants in the water 3 is sufficiently low that the deionizing stage 11 is not unduly affected by these contaminants. the water 3 would be directed from pipe 36 through valve 39 into pipe 36c.

The pretreatment of the water after it exits the residual disinfectant removal stage is complete.

In the deionizing stage 11 the cation bed 12, the anion bed 15 and the polishing bed 18 cause the exchange of ions generally found in surface water with hydrogen and hydroxyl ions, which will combine to form water molecules. Dependant upon the type and extent of ions in

the water 3, a degasification unit 53 may be added. I have found that ordinarily a degasification unit used to control and remove gases (e.g. carbon dioxide, oxygen, nitrogen) from the water is often best inserted in the system between the cation bed 12 and the anion bed 15. The placement of the unit 53 will depend on the actual configuration of the deionization stage. For instance, when only a mixed deionizer bed is used the unit 53 would be placed after such mixed bed.

The ultrafiltration stage 21 includes an ultrafilter housing 63 in which the ultrafilter membranes 24 are maintained. Colloidal and organic materials entrained in the water 3 are initially removed directly by the membranes 24 and they, therefore, congeal along the upstream surfaces of the membranes. I have found that the ultrafilter membranes when used in this manner can remove material of much lower weight than the molecular cut-off weight of ultrafilter membranes. It appears that the higher weight materials build up on the upstream surfaces of the membrane 24 and after a relatively short time the lighter weight and/or smaller sized molecules are retained in the resulting congealed layer.

In Fig. 2, a cross section portion of an ultrfilter membrane 24 is shown with porous wall 28 through which water 3 from the deionizing stage 11 (not shown) is directed. The water passing through the wall 28 is the purified water 29 and is directed to the pipe 27 (not shown). The water 3 which passes through the membrane 24 without passing through the porous wall 28 is directed to pipe 26 (not shown) and is thus, the waste water 25. The congealed matter 30 is shown as it is building up along the upstream or inside of wall 28.

The water 3 is forced through the membranes 24 at a differential pressure. In the above-described

application I have found that a differential pressure of between 25-50 psig is appropriate for forcing the water through the stage 21, with the higher end of this range pressure preferred. I have found that ultrafilter membranes manufactured by Rohmicon, a subsidiary of Rohm & Haas, and sold under the following designation are useful in practicing this invention: HF 53-20-PM10 or HF 132-20-PM10. I have had particular success with small diameter hollow fiber ultrafilter membrane, which have a molecular weight cut-off of 10,000.

As will be recognized by those skilled in the art, the buildup of the colloidal, organic and other trapped material within the ultrafilter membranes 24 requires that the membranes be periodically flushed. The method that I have used in this connection is to increase the inlet flow rate of the water to be used in such flushing from 2 1/2 to four times the normal operating "run" flow rate. The increased flow causes the removal of such entrapped material from the membranes. I have further found that cool, unheated water, due to the viscosity of such water, is more effective than warm or heated water in flushing the congealed and retained matter out of the ultrafilter membranes. After completion of such cleaning of the ultrafilter membranes, I, presently, provide the former influent portion of the ultrafilter membrane as the effluent portion of the ultrafilter membrane. Thus, for a steam generator plant, I have rotated the inlet port and the outlet port approximately every four to eight hours.

It will also be understood that the activated carbon filter, if used, the ion exchanging beds and the sand beds are cleaned or regenerated periodically in a manner that is well known within the art. The use of an activated carbon filter may concentrate the heavier

weight organics. This will enhance the effectiveness of the membranes 24 by quickly building up the congealed layer. Although not previously stated, it should be clear from the above description that the ultrafiltration membranes must have a flow of water for a sufficient time with a sufficient amount of the proper contaminates therein to form the congealed and entraining surface along the inner walls of the membrane. Thus, a recirculation of water from the pipe 27 to the polishing bed 18 or discharge of such water is appropriate during such time. The time necessary for the sufficient buildup of contaminants will be a function of the flow rate and the amount and nature of the contaminants within the water.

In using the above-described system, I have been able to obtain and produce a product water with a Total Organic Carbon (TOC) value of 30-35 ppb (or even less) on a consistent basis wherein the initial feed water was from a shallow reservoir. It is anticipated that this TOC concentration will vary with the inlet values, but such resulting TOC should not exceed 50 ppb.

As a means for confirming and testing sample water produced by this method the following test has proven effective: a) product water sample from the above-described invention is first placed in a pressurized vessel and heated, b) the vessel is then cooled, and c) the water in the vessel is analyzed for both chlorides and sulfates. It has been found that by such techniques that the ultrafiltered water, after such autoclaving, has chloride and sulfate values not exceeding 10 ppb and often less than 5 ppb, whereas analysis of water prior to passing through such ultrafilter membranes reveal chloride and sulfate values exceeding 50 ppb and even higher. I have further discovered that the colloidal

silica which is a true indicator of total colloidal content should not exceed .01 ppm. The use of the above described test on water purified by present methods for use in steam generators generally reveal chloride and sulfate values of between 50 ppb and 250 ppb and even higher.

Thus, as shall be appreciated by those skilled in the art, an apparatus and method has been disclosed and described herein which minimizes maintenance and down-time associated with the operation of steam generators. This is particularly useful in nuclear reactor steam generators where steam tube failure is a significant problem, as well as other steam generators. The present invention by eliminating the total organic compounds and colloidal matter prevents the buildup of chlorides and sulfates on the walls of such steam tubes.

Fig. 3 is a block diagram of a water purification apparatus for use in purification of water for production of United States Pharmacopeia Purified Water for use in the pharmaceutical industry. In the pharmaceutical industry, users of such water are not as concerned with colloidal and organic material in the water, so long as it is not overly concentrated. The primary or major concern in this case is the bacterial content of the final water product. Thus, raw water 3b, which may originate from a surface source or a municipal supply is directed through pipe 1b to a particulate removal stage 6b, for example, a sand filter. As will be appreciated by those skilled in the art, the flow rate through such purification facilities for water to be used in pharmacological purposes are significantly lower than those previously discussed in connection with power plants. Thus, cartridge filters using either a cotton

wound or organic polymer elements can be used instead of the previously discussed filtration devices.

The water passes from the particulate removal stage 6b through pipe 70 to the residual disinfectant removal stage 9b. This stage 6b may not be necessary dependant upon the level of disinfectants in the water. The stage 6b may include an activated carbon filter to which water is fed and an in-line ultraviolet unit which receives water passing from the activated carbon filter. Alternatively, an injection unit which introduces a reducing agent, such as sodium bisulfite, to the water can also be used. It will be understood that in most cases one or the other of the above options will be selected so that the unit constructed will have either an injection station, an activated carbon filter, or an activated carbon filter with an in-line ultraviolet unit.

As is well known, the activated carbon filter will act to remove residual disinfectant present in the water passing therethrough in the first few inches of the upper layers of the filter. Bacteria and other microorganisms will tend to rapidly grow in the lower portion of the activated carbon filter. The provision of the in-line ultraviolet unit reduces bacteria prior to the water reaching further stages in the purification and treatment process. Moreover, bacteria produced within the activated carbon filter are often of the type known as "gram negative", which is a very important concern, since such "gram negative" bacteria are often harmful to humans. It is for this reason that I prefer the sodium bisulfite injection method of remaining disinfectants for pharmaceutical applications of the invention.

From the residual disinfectant removal stage 9b, the water passes through pipe 90 to a deionization stage 11b, which functions in the manner previously described.

The water then passes to ultrafiltration stage 21b which has ultrafilter membranes 24b.

I have again found that the 10,000 molecular weight membrane which was discussed above to be appropriate in this application. The ultrafilter membranes function in the same way as described above, that is material in the water is entrained and congealed along the walls of the membrane. Water 105 for use as United States Pharmacopea Purified Water or as feedwater for distillation as water to be used in injections exits the system through pipe 27b. Waste water passing through the ultrafiltration stage 21b may, in some cases, be recirculated through pipe 105 to the mixed-bed units of the deionization stage 11b. A holding tank 109 may be provided along the path of the pipe 110. A recirculation pump 111 may also be included to aid in the recirculation and movement of the water from the ultrafilter membrane back into the mixed-bed units. The ultrafilter membranes 24b within the ultrafilter stage 11b have been found to remove bacteria which have a size of .2 microns and larger. Thus, by use of the ultrafilter, purified water with significantly reduced bacteria level may be produced than by prior methods.

The system, as described, is capable of reducing the bacteria levels to 10 Colony Forming Units/100 ml (CMU/ml) or less. The current limit by the U. S. Food and Drug Administration for bacteria in such Purified Water systems is 10 CMU/ml. Thus, the invention provides significant reduction in the bacteria over that required by regulation.

The ultrafilter membrane described herein is a significant improvement over membrane filters which the industry has used in the past. The prior-used membrane filters have a .2 micron rating so that over time

bacteria tend to "grow through" these membrane filters, whereas, the use of the ultrafilter membranes such as the types previously discussed inhibits such growth. The ultrafilter membranes of my system are also periodically cleaned with an oxidizing agent which is, in fact, a disinfectant. With weekly cleaning there is only a ten-fold increase in bacteria levels between cleaning operations.

Fig. 4 is a block diagram of a municipal purification system according to the present invention. In this embodiment raw water 3c is fed through a pipe 1c to a particulate removal stage 6c, for removal of gross particulate matter present in the raw water supply. The water is then directed to an ultrafiltration stage 21c through pipe 123. The ultrafiltration stage 21c includes ultrafilter membranes 24c through which the water 3c is directed. Waste water 25c exits the stage 21c through pipe 26c. Filtered water exits the stage 21c through the pipe 27, and passes to the diinfecting stage 126.

The ultrafilter membranes 24c will act to retain collodial and organic material. The use of a 10,000 molecular cut-off weight ultrafilter membranes should adequately remove the material known as "trihalomethane precursors", which are the materials which react with chlorine to produce trihalomethanes.

In the case of a placid reservoir or lake supply not having significant quantities of such particulate matter which is drawn into the treatment apparatus, the water can pass directly to the ultrafiltration stage 21c.

In this case there has been no removal of ionic material from the water. I have come to believe that the absence of the ionic material in the previous discussed embodiment promotes the removal of the lighter molecular weight species below the 10,000 molecular weight cut-off,

therefore, in this case it appears that only some of the lighter molecular weight material will be removed by ultrafiltration, however, as previously described the "trihalomethanes precursors" are removed.

The water passing from the ultrafilter membranes 24c in the stage 21c can then be treated with a disinfectant in the disinfectant stage 126, in a manner commonly used in water treatment, such as chlorination. The water thus treated and purified can then flow to a storage or supply facility or directly to the ultimate users or various holding facilities.

This embodiment permits the use of chlorine as a disinfecting agent without the production of cancer-causing agents which are generally classified as trihalomethanes (THM) which are produced by the reaction of chlorine a commonly used disinfecting agent in municipal water supplies, with heavy molecular weight organic substances such as humic acid. I have found that the removal of such heavy weight molecules of humic acid permits the chlorination of water without the production of trihalomethanes.

In Fig. 5, a "general" embodiment of this invention is shown which can be used in the food and beverage industry, a point of use filter for domestic applications, or in a variety of other industrial applications where colloidal and organic material interfere significantly with the final use of the water. This embodiment generally has a particulate removal stage 6d, a lighter molecular weight organic substance pre-removal stage 175, and an ultrafiltration stage 21d.

Raw water 3d, which may originate from a surface water source or a municipal supply, is directed through pipe 1d to the particulate removal stage 6d. The water 3d passing through the stage 6d is directed through pipe

178 to the stage 175. The water 3d then passes through pipe 181 to the ultrafiltration stage 21d which includes ultrafilter membranes 24d. Waste water 25d exits the stage 21d through pipe 26d, and purified water for use 183 passes through the pipe 27d.

In this instance, the feedwater 3d is fed to the particulate removal stage 6d wherein gross particulate matter is removed from the water. Again, depending upon the nature of the water 3d this particular step may be omitted. The water 3d is then fed to the lighter molecular weight organic pre-removal stage 175. This is essentially an injection stage where a filtering aid such as cationic polymers, powdered activated carbon or powdered aluminas, would be added to the water. Each of these materials have the ability to remove lighter molecular weight organic material from the feedwater 3d, as said water is passed through the ultrafiltration stage 21d. This particular stage is necessary in the operation of this embodiment, as the ultrafilter membrane 24d are not provided with relatively ion-free feedwater which reduces the effectiveness of the ultrafilter membrane in removing lighter molecular weight organic substances. Thus, I believe the use of such filtering aids promotes the establishing of a coating on the ultrafilter membrane which improves the effectiveness in removing lighter molecular weight organic substances below the actual molecular weight cut-off of the ultrafilter membrane itself.

Further, in the cleaning of the ultrafilter membrane to remove organic material retained therein, an additional stage may be added in that the water and matter flowing from the ultrafilter membrane through pipe 26d during cleaning can be passed through an organic removal stage 185 having an organic removal agent. An

appropriate organic removal agent such as sodium hydroxide could be utilized. The agent functions to separate the organic material from the portion of the filtering aid which was retained by the ultrafilter membrane prior to cleaning. The organics thus separated from the filtering aid are then directed through pipe 193 to the waste water 25d. The recovered filtering aid is then recycled through pipe 195 to the lighter molecular weight organic removal stage 175.

By proper use of the filtering aid, I believe it is possible to remove material with relatively low molecular weight such as trihalomethane and trichlorethylene. Trichlorethylene is a contaminant often found in municipal water supplies resulting from piping materials which were utilized in the late 1970's. Thus, the embodiment shown in Fig. 5 permits production of water which is low in colloidal matter and bacteria. Further, light molecular weight organic constituents are removed by this process. The use of activated carbon as the filter aid in the stage 175, would cause the residual concentrations of disinfecting agents to be thereby removed. Also, since the use of the activated carbon is not maintained in a depth bed production of bacteria resulting from the use of activated carbon is inhibited.

Thus, as will be seen from the foregoing, I have discovered and taught the apparatus and methods for producing essentially pure water from surface water sources having a variety of contaminants therin. I have further taught a means for purifying water from municipal or other treated water sources. The water can be produced through these processes in a variety of methods to be tailored to the end-use by the users of embodiments herein.

It will be further appreciated by those skilled in the art that other modifications other than those directly taught herein, can be made into this invention without departing from the spirit and scope of the invention and that such modifications, changes, additions, and deletions of steps and apparatus are contemplated herein.

CLAIMS

1. A water purification and treatment process for use in the production of purified water comprising the steps of:

a) directing water from a source to an ultrafilter membrane;

b) filtering said water through said ultrafilter membrane; and

c) disinfecting said water after said filtering step, whereby purified water is produced.

2. A process according to claim 1, wherein said purified water is adapted for human ingestion, said step of filtering removes substantially all trihalomethane precursors, and said step of disinfecting the water includes chlorinating the water whereby production of trihalomethanes is inhibited by the removal of the trihalomethane precursors prior to said step of disinfecting.

3. A process according to claim 2 further comprising the step of removing particulate matter in said water prior to said step of directing said water to said ultrafilter membrane, whereby particulate matter in said water is removed thereby.

4. A process according to claim 3 wherein said removing step includes passing said water through a filtration bed which retains said particulate matter.

5. An apparatus for the purification of water for use,

said apparatus comprising:

a) an ultrafilter membrane; said membrane being connected to a water source;

b) means for directing water to be purified to said ultrafilter membrane;

c) said membrane removes and retains trihalomethane precursors and other organic contaminants in said water, as said water is passed through said membrane;

d) means for disinfecting said water after said water has passed through said membrane, whereby production of trihalomethanes are thereby significantly reduced due to the elimination of trihalomethane precursors by said ultrafilter membrane and essential purified water for use is attained thereby; and

(e) means for operatively connecting said ultrafilter membrane with said means for disinfecting.

6. An apparatus according to claim 5 wherein said means for directing water to said ultrafilter includes a pretreatment filter and said pretreatment filter aids in the removal of particulate matter in said water so that the water directed to said ultrafilter membrane is substantially free of particulate matter such that said water passing through said apparatus is adapted for human ingestion.

7. An apparatus for the treatment of surface water comprising:

a) pretreatment means for the removal of particulate matter in said water;

b) means for directing water for treatment to said pretreatment means;

c) deionizing means, which replaces ions in the water with hydrogen and hydroxyl ions;

d) second means for directing water from said pretreatment means to said deionizing means; and

e) an ultrafilter membrane operatively connected to said deionizing means, whereby said apparatus retains substantially all sulfates and chlorides within the water, whereby the water passing through said apparatus is substantially free of all sulfates and chlorides, including sulfates and chlorides which are released by thermal degradation.

8. An apparatus according to claim 7 wherein said pretreatment means further includes means for removing residual disinfectants within said water such that said water passing through said apparatus is adapted for use in steam generators.

9. An apparatus according to claim 7 wherein said pretreatment means includes a depth filter through which said water is passed to remove said particulate matter.

10. An apparatus according to claim 7 wherein said membrane, as said water passes therethrough, retains and removes from said water organic and colloidal material, including, over time, organic and colloidal material having a lower molecular weight than the molecular cutoff weight of said membrane.

11. An apparatus according to claim 10 wherein said

ultrafilter membrane has a molecular weight cut-off of approximately 10,000 daltons or less.

12. An apparatus according to claim 8, wherein said pretreatment means to remove residual disinfectants includes injecting sodium bisulfite into said water to remove residual disinfectants within said water.

13. A water purification and treatment process for use in the production of purified water comprising the steps of:

a) removing particulate matter in said water;

b) deionizing said water;

c) congealing contaminants, including organic and colloidal matter in said water; and

d) retaining said congealed contaminants in saidultrafilter membrane, whereby the water passing through the process is purified such that the water is substantially free of organic and colloidal matter.

14. A process according to claim 13 further comprising the step of removing residual disinfectant in said water wherein said water purified by said process is adapted for use in steam generators.

15. An apparatus for the production of pure water from surface water sources comprising:

a) a pretreatment stage for removal of particulate matter in raw water;

b) said pretreatment stage having means for receiving the raw water from a surface water source;

c) an ultrafiltration stage which receives the water passing from said pretreatment stage;

d) said ultrafiltration stage includes an ultrafilter membrane which substantially removes all bacteria, organic matter, and colloidal matter in said water, whereby water substantially free of bacteria, organic matter, particulate matter, and colloidal matter is thereby produced.

16. An apparatus according to claim 15 wherein pretreatment stage further includes means for removing residual disinfectants in the water.

17. An apparatus according to claim 15 wherein said pretreatment stage includes a filter for retaining said particulate matter.

18. An apparatus according to claim 16 further comprising ion exchanging means, wherein ions in the water are replaced with hydrogen and hydroxyl ions; and

said ion removal means being positioned between and operatively connected with said pretreatment stage and said ultrafiltration stage, wherein said ultrafilter membrane retains bacteria, organic matter and colloidal matter having a molecular weight substantially below the ultrafilter membrane molecular cut-off weight size.

19. An apparatus according to claim 15 wherein said

ultrafilter membrane has a molecular weight cut-off size of approximately 10,000 daltons or less.

20. An apparatus according to claim 18 wherein said ultrafilter membrane has a molecular cut-off weight of 10,000 daltons or less.

21. A water purification and treatment apparatus for use in the production of purified water comprising:

a) pretreatment means for removing particulate matter in said water;

b) means for deioninzing said water by ion exchange;

c) an ultrafilter membrane for removing bacteria in said pretreated and deionized water, whereby said bacteria are entrained and caught within said ultrafilter membrane;

d) said pretreatment and deionizing means being operatively connected; and

e) said ultrafilter positioned to receive water passing from said pretreatment and deionizing means.

22. An apparatus according to claim 21 wherein said pretreatment means includes means for removing residual disinfectants within said water, and said means for removing residual disinfectants, a carbon filter and an inline ultraviolet light for bacteria control wherein said water passing through said apparatus is adapted for use in the pharmaceutical industry.

23. An apparatus according to claim 21 pretreatment means includes means for removing residual disinfectants within said water, and said pretreatment means and said means for removing residual disinfectants includes means for the injection of sodium bisulfite to said disinfectants wherein said water passing through said apparatus is adapted for use in pharmaceutical industry.

24. A water purification and treatment process for the purification of water, for use in pharmaceutical industry, said process comprising the steps of:

a) removing particulate matter from said water;

b) deionizing said water by ion exchange; and

c) filtering said water through an ultrafilter membrane, whereby water passed through said process is substantially free of ions, colloidal matter, organic material, and bacteria.

25. A water purification and treatment process as claimed in claim 1 employing apparatus substantially as described herein with reference to Figs. 1 and 2, Fig. 3, Fig. 4, or Fig. 5 of the accompanying drawings.

26. An apparatus for the purification of water as claimed in claim 5 substantially as described herein with reference to Figs. 1 and 2, Fig. 3, Fig. 4 or Fig. 5 of the accompanying drawings.